# OPTIMIZATION OF MYCELIUM GROWTH USING GENETIC ALGORITHM FOR MULTI-OBJECTIVE FUNCTIONS

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## ABSTRACT

Optimization of mycelium growth is a process that are aim to get the optimal value for growing mushroom. Mathematical optimization was typical use for such problem, in which it was supposed to maximizing or minimizing a function. However, for optimizing mycelium growth, there are more than one function that needs to be calculated and solved, making this problem as a multi-objective optimization problem. Multi-objective optimization has become common issues discussed in many fields of study. The traditional method of the optimization requires various degree of understanding and analyzation of multiple things such as the importance of an objective against the other objectives. Trade-off between the objectives, exist for the optimization process. To solve this issues, multi-objective genetic algorithm was chosen as the methodology for this project, specifically using NSGA-ii algorithm. In order to achieve such goal, several research papers related to mycelium and mushroom has been selected as part of the materials for literature review. Several papers related to genetic algorithm and objective optimization were also included. The nitrogen concentration and the mycelium extension rate of are two objectives problem that need to be solved. Through the implementation of selected multi-objective genetic algorithm, NSGA-ii was able to produce pareto front for optimizing both nitrogen concentration and the extension rate of the mycelium. Based on that result, it is concluded that multi-objective optimization problem can be solve using the applied method.

# ABSTRAK

Pengoptimuman pertumbuhan miselium adalah proses yang bertujuan untuk mendapatkan nilai optimum untuk menanam cendawan. Pengoptimuman matematik adalah penggunaan biasa untuk masalah seperti tersebut, di mana ianya untuk memaksimumkan atau meminimumkan fungsi. Walau bagaimanapun, untuk mengoptimumkan pertumbuhan miselium, ada lebih daripada satu fungsi dimana ianya perlu dikira dan diselesaikan, menjadikan masalah ini sebagai masalah pengoptimuman pelbagai objektif. Pengoptimuman pelbagai objektif telah menjadi isu biasa yang dibincangkan dalam banyak bidang pengajian. Kaedah pengoptimuman tradisional memerlukan pelbagai tahap pemahaman dan analisa pelbagai perkara seperti kepentingan suatu objektif terhadap objektif lain. Perdagangan antara objektif, wujud untuk proses pengoptimuman. Untuk menyelesaikan masalah ini, algoritma genetik pelbagai objektif dipilih sebagai metodologi untuk projek ini, khusus menggunakan algoritma NSGA-ii. Untuk mencapai matlamat tersebut, beberapa kertas penyelidikan yang berkaitan dengan miselium dan cendawan telah dipilih sebagai sebahagian daripada bahan-bahan untuk semakan kesusasteraan. Beberapa kertas yang berkaitan dengan algoritma genetik dan pengoptimuman objektif juga dimasukkan. Kepekatan nitrogen dan kadar lanjutan mycelium adalah dua masalah objektif yang perlu diselesaikan. Melalui pelaksanaan algoritma genetik pelbagai objektif yang dipilih, NSGA-ii mampu menghasilkan pareto depan untuk mengoptimumkan kepekatan nitrogen dan kadar lanjutan dari miselium. Berdasarkan hasil tersebut, disimpulkan bahawa masalah pengoptimalan multi-objektif dapat diselesaikan dengan menggunakan kaedah yang diterapkan.

## TABLE OF CONTENT

## LIST OF TABLES

## LIST OF FIGURES

## LIST OF ABBREVIATIONS/ACCRONYM USED

| | |
|---|---|
| GA | Genetic Algorithm |
| ANN | Artificial Neural Network |
| EPS | Extracellular Polysaccharide Exopolysaccharide |
| UMP | *Universiti Malaysia Pahang* |
| NSGA | Non-Dominated Sorting Genetic Algorithm |
| GA-ANN | Genetic Algorithm–Coupled Artificial Neural Network |

# CHAPTER 1

# INTRODUCTION

## 1.1 Introduction

**Figure 1 Mycelium of Oyster mushroom (Pleurotus Ostreatus)**

Mycelium is a part of fungus or that are consists of long and branching thread-like structures. If large enough, mycelium can be observed with naked eyes. It is used by the fungus to absorb nutrients around its environment. Usually, the larger the mycelium, the large the fungus will be. Industry that commercialize fungus cultivate them in special environment, so that the factor that affect the growth such as temperature and humidity can be controls. In most cases, the factors are controlled so that the mycelium can grow large.

In order to find the best value for the factors, several optimizations have been done toward the growth of the mycelium. Optimization process usually done by analyzing

on how the factors affect the mycelium. Using mathematic, mathematical optimization has been implemented into the optimization, where a single function contains a chain of expression that represent the factors. As better optimization process was discovered, mathematical optimization which is a single objective optimization were later then replace with multi-objective optimization.

Through multi-objective optimization, a set of optimum solution can be acquired. There are several methods that can be used for multi-objective optimization. One of it is to convert the objectives into a single algorithms or objective function with a set of weighted sum method. Weighted sum method is effective for single objective optimization problems, and is very effective to be use because the weights in the algorithm or function can be adjusted depending on the priority of the objective, however the method are actually less affective for multi-objective optimization problem.

Another method is by using Genetic Algorithm (GA) as part of the multi-objective function. Genetic Algorithm is a concept that is based on evolution theory that exists to explain the origin of species. In theory, species that are weak and unfit are cease to extinct, while the strongest and fittest will continue to evolve, either through genes mutation or crossover.

## 1.2 Problem Statement

Optimization of the mycelium growth can be accomplished with the use of genetic algorithm. Implementing the genetic algorithm into the optimization process can be tricky, as no reference or design available to be use directly, therefore understanding how the implementation work can be very useful. Genetic algorithm meant to be use to solve the objectives functions. The solved objectives functions will produce value that should be optimal for mycelium growth. It is not known whether the produced output is optimal or not, so the operation needed to be run multiple times. The output then needed to be analysed first, before it can be confirmed to be optimal.

## 1.3 Objectives

i) To design a multi-objective optimization using genetic algorithm for mycelium growth

ii) To implement a genetic algorithm for multi-objective optimization for mycelium growth

iii) To validate the optimization of the mycelium growth

## 1.4 Scope

The scope of this research is to optimize the growth of mycelium growth by implementing genetic algorithm, more specifically by implement NSGA-ii to solve the multi-objectives problem, in which the generated output is only used to create pareto front.

## 1.5 Thesis Organization

From start to finish this thesis consists five chapters. For chapter 1 discusses about the overall overview of this project. In this chapter, the problem statement was identified and explained. Based on the problem statement, the project objectives were set in this chapter along with the scopes that needs to be cover. The scope was thought carefully to avoid confusion in the future.

Chapter 2 is about literature review. In this chapter we will talk about other research papers that are related to this project's topic. Several research papers will be selected and listed down for review. The purpose of the review is to identify and study the problem statement, methodology that are used and the result of the previously conducted research.

Chapter 3 is about the methodology for this project. Inside this chapter, we will explain about the multi-objective optimization. The flow of the optimization process also be shown here. Later at the end of this chapter, we will discuss about how to verify and test the optimization process.

Chapter 4 is about the implementation. In this chapter, the proposed methodology in chapter 3 are implemented. This chapter will also include some discussion and report on how the implementation are done.

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